India in the Eye of a Perfect Cooling Storm – Can Strong Policies and Technological Innovations Help Achieve "Thermal Comfort for All"

Dr. Satish Kumar, President & Executive Director, AEEE

About AEEE

- AEEE's Vision and Theory of Change
- Core Focus
- AEEE Network
- Organisational Structure


AEEE’s vision: To catalyse India’s transformation into a global leader in the field of energy efficiency through thought leadership and enabling programs
Indian Remote Sensing Satellites
Indian Space Research Organisation
500 km

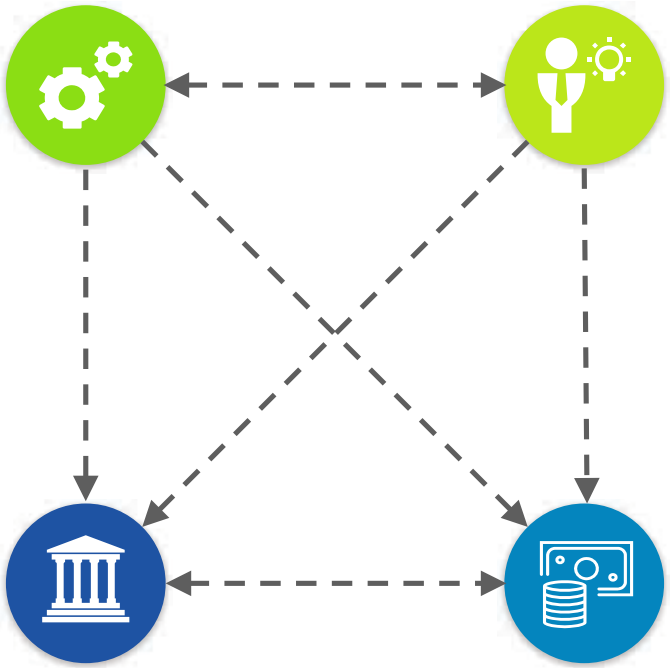
AEEE: Preferred Partner of Govt. & Market

EE INDUSTRY PLATFORM

Create a credible EE platform to advocate business-enabling policies and develop a collaborative ecosystem

THINK TANK

Develop thought leadership position by nurturing innovative technologies and business models



POLICY ENABLEMENT

Advocate futuristic, holistic and data-driven EE policy that fosters innovation and entrepreneurship

MARKET ENABLEMENT

Work with public and private sectors to create and enable widely adopted business value propositions

Converting Inspiration to Intervention: With Four Programs

Alliance for an Energy Efficient Economy

1 EE Finance and ESCO

- Facilitation Services for ESCOs - Create $1 billion market
- Standard ECMs and M&V methods to scale up the market
- Future Energy Services Trends

2 Buildings, Systems and Technologies

- National flagship policies
- Leadership in high impact areas
- Energy data disclosure

3 Urban Infrastructure

- Tapping state and municipal agencies and programs for EE
- Energy and resource efficiency through transportation

4 Business and Industry platform

- Bringing industry, government and market together
- Training and Capacity Building

Funders

gef, UNDP, giz, MacArthur Foundation, SHAKTI Sustainable Energy Foundation, World Bank

Partners

ACEEE, icct, NRDC, USGBC, World Resources Institute

Research institutes

Berkeley Lab, CEPT University, U.S. Department of Energy, Stanford

AEEE's Collaboration with Key Govt Bodies

Government of India

Ministry of Power, Coal, Natural & RE

Ministry of Environment, Forests & Climate Change

Ministry of Science & Technology

NITI *Aayog*

Bureau of Energy Efficiency

- Leading AEEE's State EE Index initiative, in facilitation with SDAs
- Partnering for a $1 billion ESCO market,
- ECBC implementation w/ key inputs on residential public draft

Ministry of Environment, Forests & Climate Change

- Thermal Comfort for All report -> core strategy for National Cooling Action Plan (NCAP)
- Leading the Building and Cold Chain section of National Cooling Action Plan

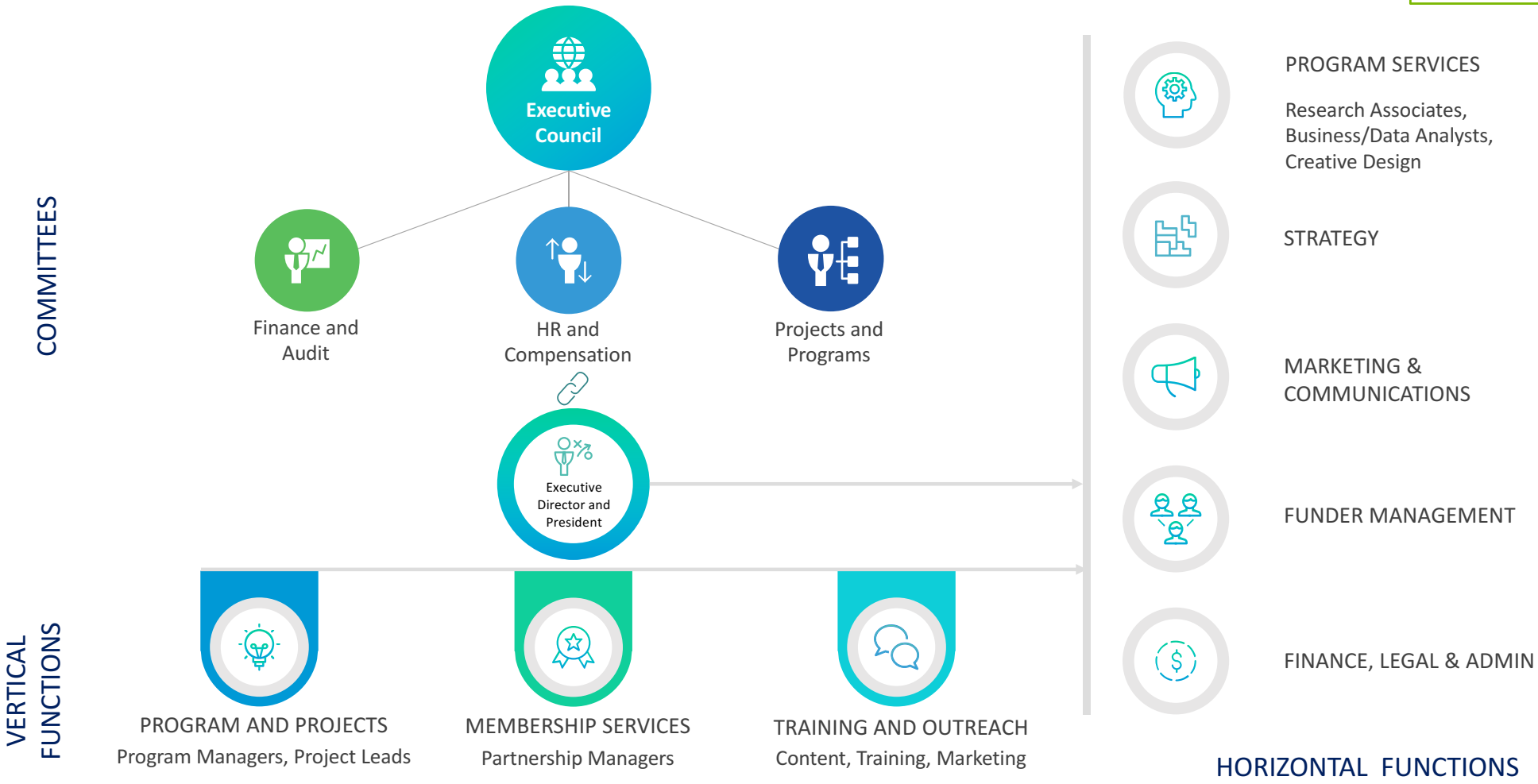
Department of Science & Technology (DST)

- Chairing Proposal Evaluation Committee for Initiative to Promote Habitat Energy Efficiency (I-PHEE)
- Steering Committee -> Global Technology Watch Groups (GTWG) for National Action Plan on Climate Change (NAPCC)

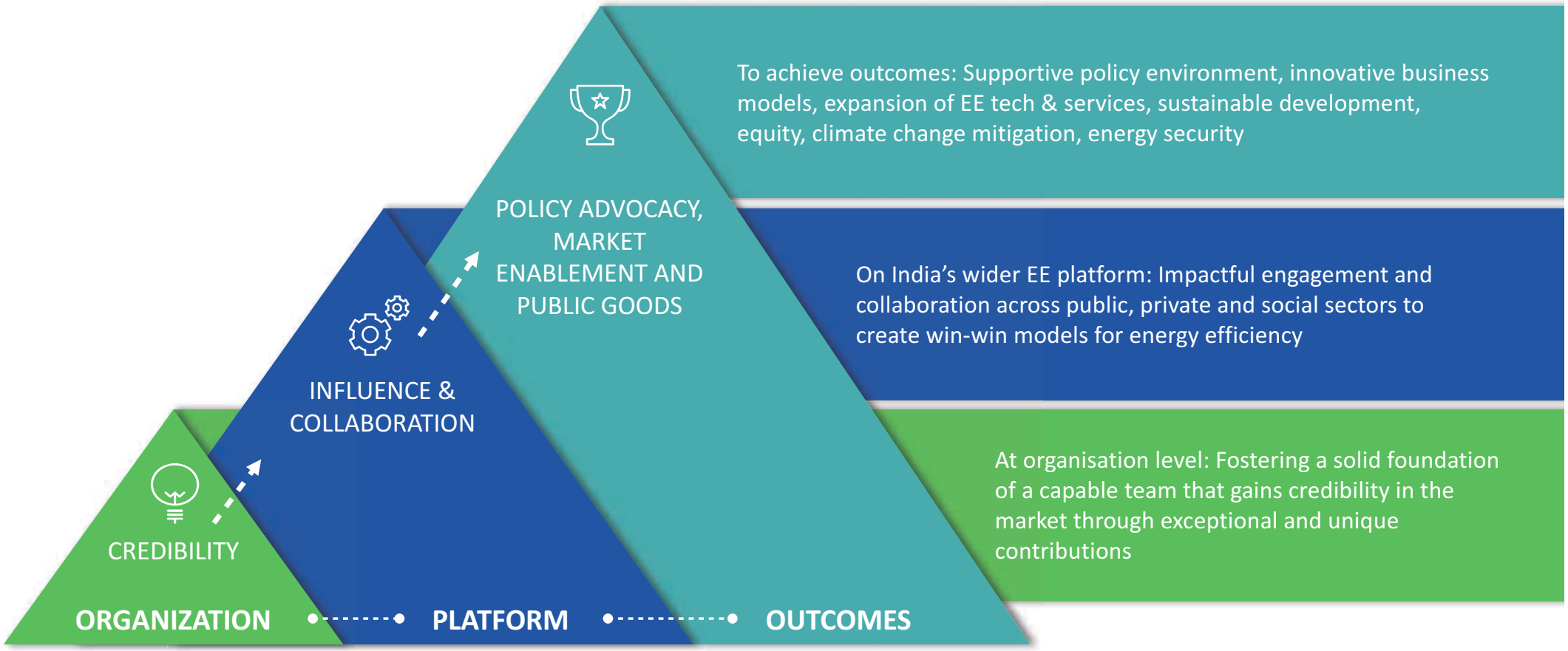
National Institution for Transformation of India (NITI) Aayog

- ECBC Implementation
- Provide inputs on the EE sections of National Energy Policy
- Member of the task force for National Energy Data Mgmt framework;
- Partner in AEEE's State EE Index

Structure of the Organization



Strategy to take AEEE to next level

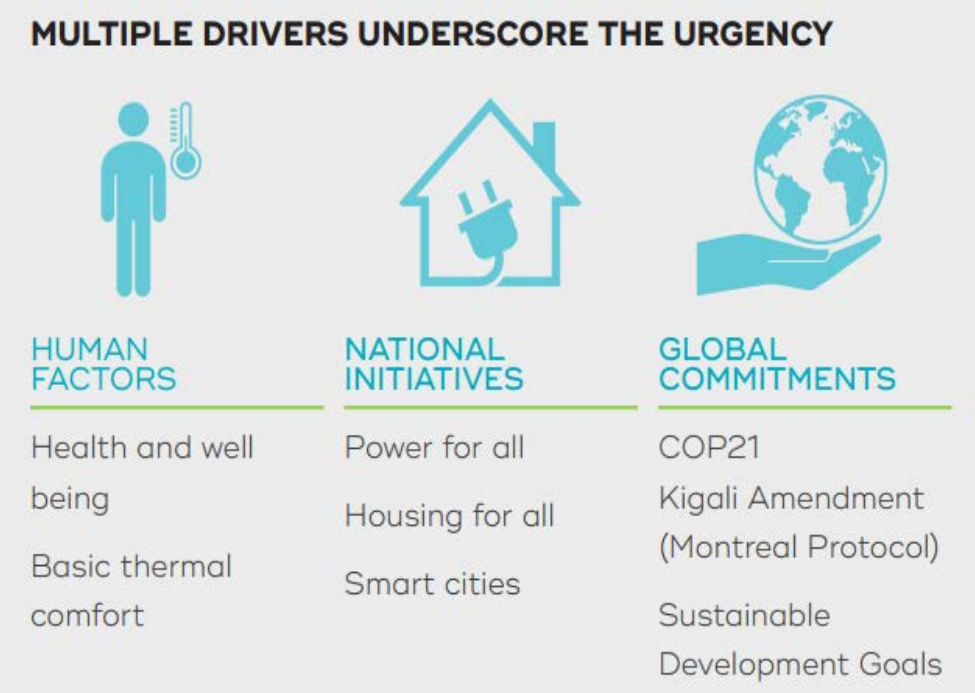


Context

- India, in the Eye of the Perfect ‘Cooling’ Storm
- Potential Impact: Keeping Our Buildings Cool
- Recognising the Uniqueness of India’s Cooling Conundrum is Foundational to AEEE’s Approach

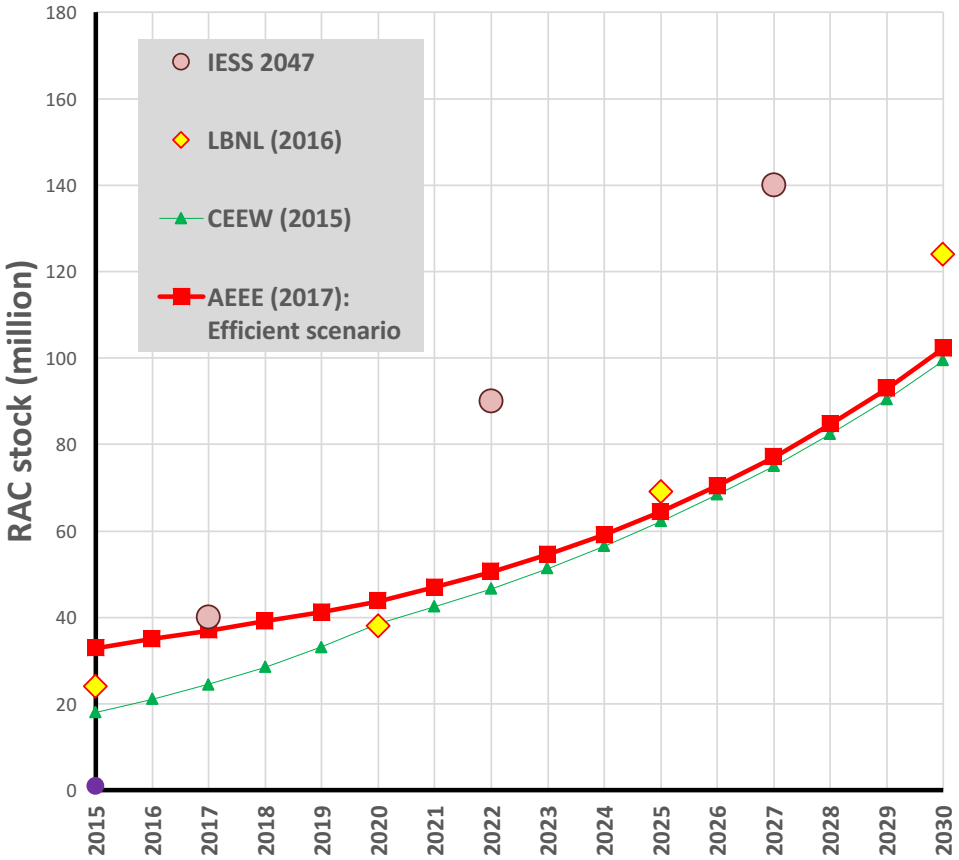
India, in the Eye of the Perfect 'Cooling' Storm

- A growing population (~1.3 billion)
- Tropical climate and rising temperatures (3120 annual CDDs)
- A rising aspirational middleclass
- Increasing built-up area (2-3x by 2030 over 2015 baseline)
- A low RAC penetration (5-10%)
- National and global commitments



How do we provide thermal comfort to *all* in an affordable and sustainable manner, and uphold basic standards of human well-being?

Potential Impact: Keeping Our Buildings Cool



- Multiple studies unanimously project a significant increase the RAC stock
- Severe environmental and societal impacts:
  - Significant additional power generation capacity
  - peak load impacts
  - enormous carbon footprint, both direct and indirect

Recognising the Uniqueness of India's Cooling Conundrum is Foundational to AEEE's Approach

❖ Cooling is not Air-Conditioning – Important in India

- RAC penetration 5-10% V/S 100+ % AC penetration in developed countries
- Prevalent alternative cooling technologies significantly higher in volume: significantly lower kWh/unit; zero refrigerant use

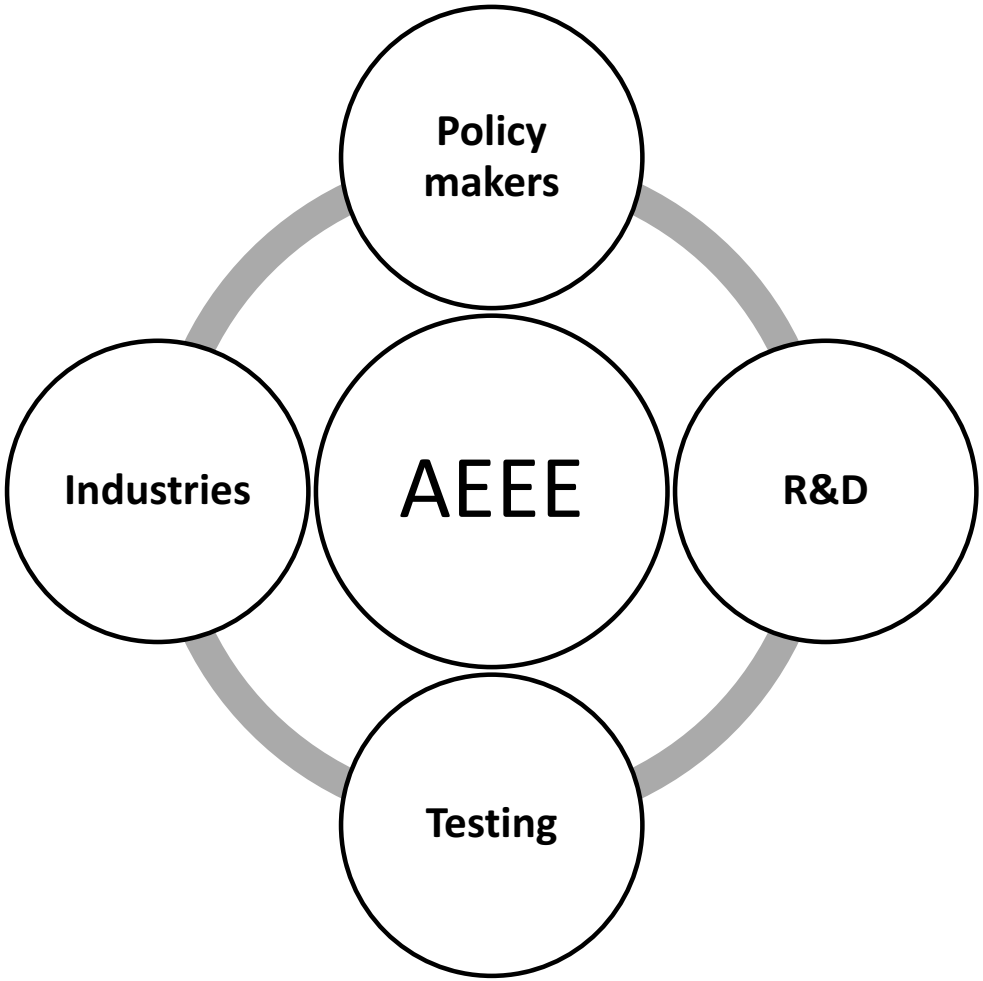
❖ The majority of AC and refrigerant volume is yet to come

- *Unique opportunity* to address the very root of the problem, by minimizing the demand for cooling

❖ Conversations around cooling need to be all-encompassing i.e. active space cooling + alternative cooling strategies

- We will not get to a point – even in the next 10-15 years – when majority can afford air-conditioning

AEEE's Unique Position



AEEE is Uniquely Suited to Lead India's Transition to a Sustainably Cooled Future

- **Government's focus to establish access to cooling as a national priority is synchronous with AEEE's drive to enable sustainable and accessible thermal comfort for all**

- **Access to deep subject matter expertise through affiliations with knowledge partners and peer organisations**

- **Subject-matter expertise in space cooling, & unprecedented work with important ramifications:**
  - Psychrometric field tests of RACs to study their energy performance at different temperature set-points
  - First-of-its-kind comprehensive overview of nationwide cooling demand by sector
  - Nationwide survey to understand the residential RAC usage patterns
  - Catalysing the formation of Smart and Sustainable Space Cooling
  - Coalition to lead India's transition to a responsibly cooled built environment

Key Initiatives

- Sustainable and Smart Space Cooling Coalition
- Projecting National Energy Savings Estimate from Space Cooling Strategies
- Demand Analysis of Cooling in India for 2017 and 2027
- Government of India’s National Cooling Action Plan

Key Initiative 1: Sustainable and Smart Space Cooling Coalition

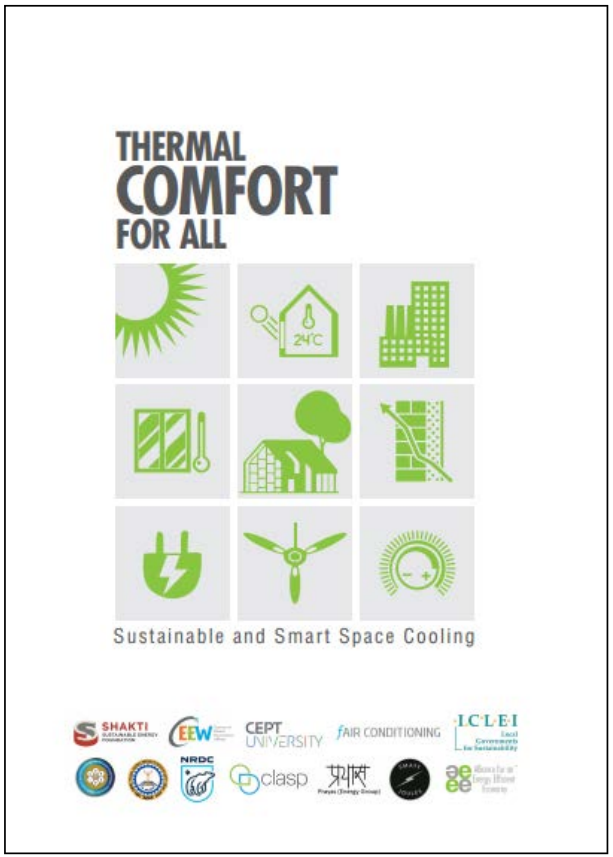
AEEE catalyzed the formation of Smart and Sustainable Space Cooling Coalition to lead India's transition to a responsibly cooled built environment

Vision:
To **recommend and promote** the **adoption of *Lean, Mean and Green* space cooling strategies** to meet India's thermal comfort needs.

Mission:
To **lead India's transition to a sustainably cooled built environment** by supporting advanced research, analysis, joint policy recommendations and by facilitating market transformation.

Core Coalition Activities:
- Collaborate with industry associations, think-tanks and academic institutions to advance the momentum on sustainable space cooling initiatives
- Jointly publish technology alerts and newsletters demonstrating the seamless commingling of different perspectives on space cooling in one definitive and effective voice

Sustainable and Smart Space Cooling Coalition (Phase 1) Project: Thermal Comfort for All



LEAN
Minimise cooling needs

MEAN
Achieve cooling efficiently

GREEN
Displace carbon footprint

The Lean, Mean, Green construct is foundational to the *Thermal Comfort for All* project

(Based on the Lean-Mean-Green concept by Bordass et al, 2001)

- **AGGREGATES the current body of knowledge, potential challenges, and the wide-ranging benefits of sustainable cooling strategies**
- **PROPOSES RECOMMENDATIONS designed to promote the vision of thermal comfort for all**

Sustainable and Smart Space Cooling Coalition (Phase 2)

Alliance for an Energy Efficient Economy

EXPLORATION OF THE TECHNO-ECONOMIC FEASIBILITY OF LOW ENERGY COOLING TECHNOLOGIES

- A deep dive into low energy cooling technologies suitable in Indian conditions: **Radiant cooling, Structure cooling, Indirect-direct evaporative cooling, Hybrid cooling (Desiccant + conventional VCS), Ground source heat pumps, Earth-air tunnel heat exchanger, Solar air-conditioning and Solar-wind hybrid systems**
- An extensive survey of manufacturers: **Feasibility- technology, Climate, Equipment, sector application, O&M, Market outreach, Financial viability, Future scope**
- This exercise will help identify the potential market inhibitors for penetration of these sustainable technologies

TOWARDS DESIGNING A WINDOWS LABELING PROGRAM FOR INDIA

- Reviewing international glazing and window labeling programs
- Sensing the gaps and challenges in the creation of an overarching windows labelling program by conducting joint stakeholder consultations
- Status of Bureau of Indian Standards (BIS) labeling program and its inclusion in the Energy Conservation Building Code (ECBC)

Key Initiative 2: Projecting National Energy Savings Estimate from Space Cooling Strategies

Alliance for an Energy Efficient Economy

Impact of ADAPTIVE THERMAL COMFORT on air-conditioning usage patterns and on the resulting nation-wide energy savings

- Estimation of the energy consumed by air-conditioning in residential and commercial buildings
- Psychrometric field testing of RACs to study energy consumption v/s temperature setpoint
- Evaluation of nation-wide energy savings through the adoption of adaptive thermal comfort standards
- Recommendations to bridge policy gaps to effect the benefits of adaptive thermal comfort

Impact of use of use of HIGH PERFORMANCE GLAZING AND WELL-DESIGNED WINDOW/FENESTRATION SHADING strategies on cooling demand

- Theoretical assessment of energy saving opportunities
- Preliminary industry engagements to explore the possibility of developing mandatory energy rating labels for windows
- Evaluation of key policy options

BERKELEY LAB

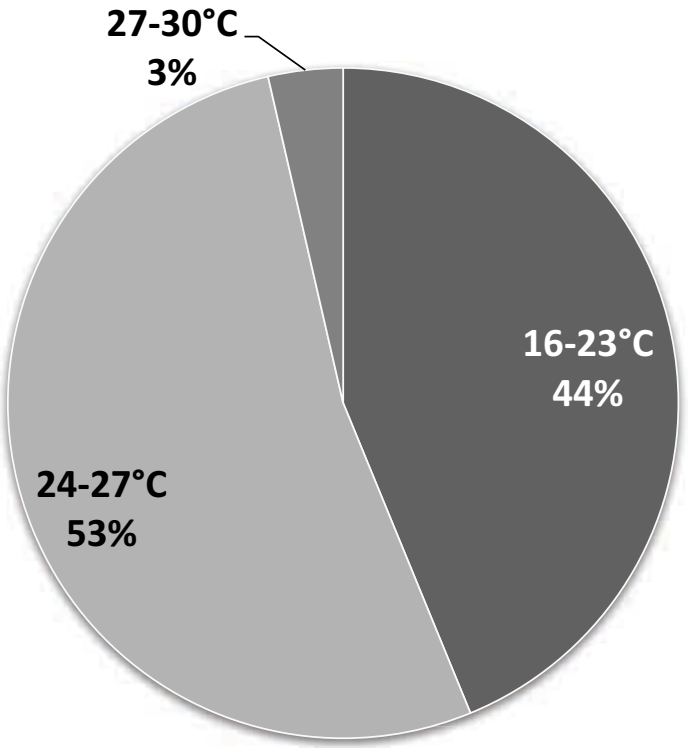
CEPT UNIVERSITY

Mapping the Use of RACs in Indian Homes: A Nation-wide Survey

- Premised on the knowledge gap of people's RAC use preferences, especially setpoints
- Short, anonymous, easy to fill out, comprising 13 questions
- **Administered online**, popularised on social media
- **Physically administered** with the help of student-surveyors in the 6 cities, particularly focussing on low to mid-income classes
- **995 responses**
- **Responses have been collected from 28 states/UTs, covering 100+ towns and cities** – Delhi-NCR, Maharashtra, Tamil Nadu, Telangana and Rajasthan top the list.
- Responses cover household sizes ranging from 1-10 members, however about 70% of the data set is homes with 2-5 family members

Mapping the Use of RACs in Indian Homes: A Nation-wide Survey (contd.): Basic Findings

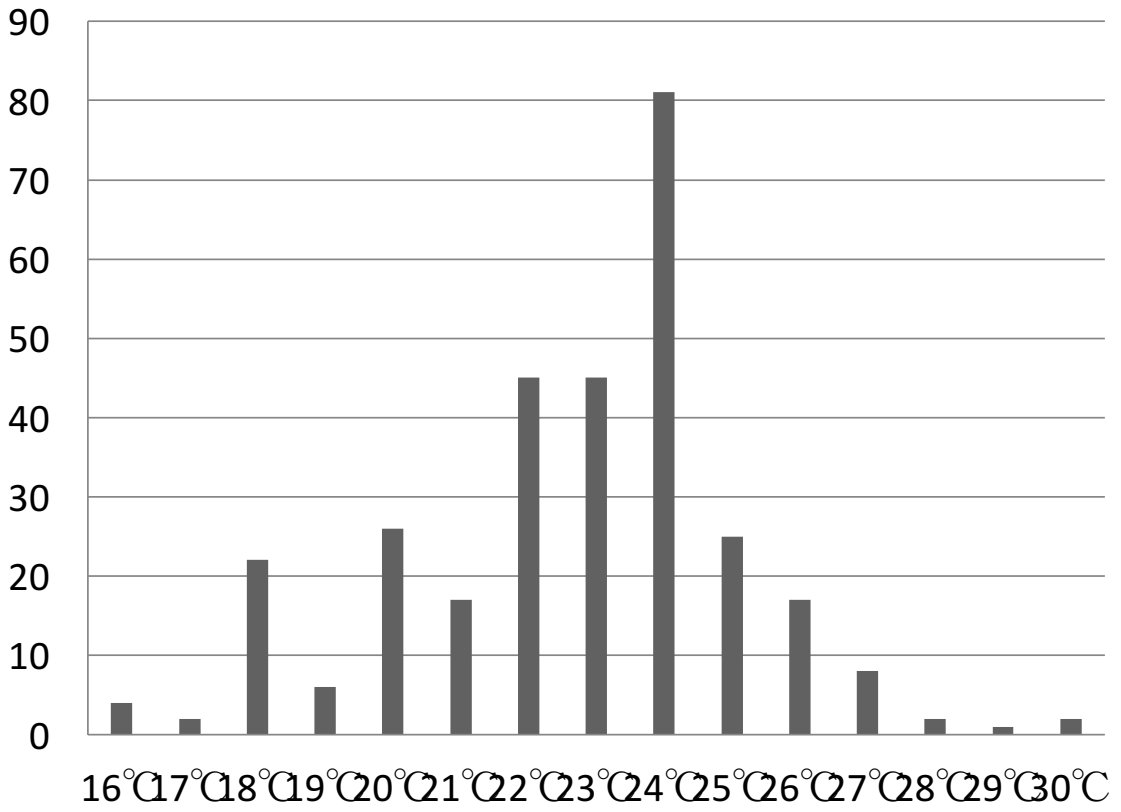
- Majority respondents indicated that they also use a fan while operating the AC
- A mean of 1.73 ACs are used per household
- 3-star, <3 years, and 1.5 tonnes were the most recorded star-rating, age, and tonnage of ACs, respectively
- 66% of ACs are split type
- While ACs typically operate between 4-8 hours from March to October, they usually remain switched-off from November to February



Setpoint distribution

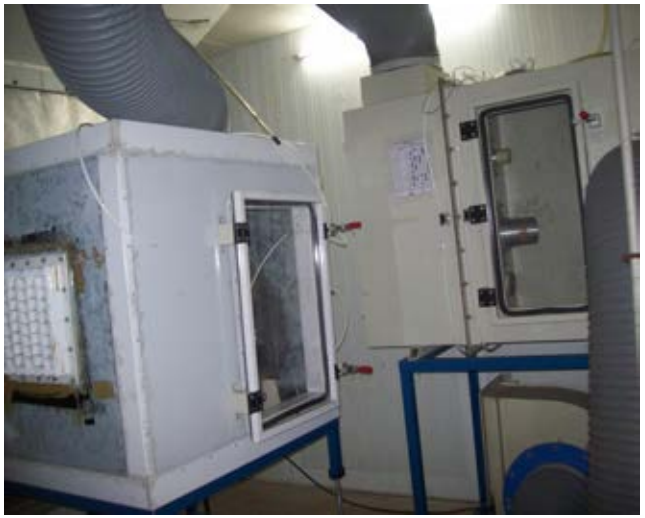
Mapping the Use of RACs in Indian Homes: A Nation-wide Survey (contd.): Preliminary Analysis

- Climate type: Warm-humid
- 299 responses
- Fan use with RAC ON: 59% Yes, 41% No
- Annual hours of use: 1421



Psychrometric Field Testing of RACs in partnership with CEPT

- Aims to study the energy savings in RACs by the adoption of adaptive thermal comfort standards in India.
- Experiments are meticulously designed to capture diverse Indian climates by emulating typical outdoor conditions
- Performance evaluation of two leading Indian AC brands with different star ratings and cooling technologies – by comparing the cooling capacity and EER
- Initial analysis reveals:
  - Inverter systems offer better performance over regular split air-conditioners.
  - Increasing outdoor temperatures have a negative effect on the performance of the system.
  - ***Higher setpoints result in higher energy consumption – needs more investigation***

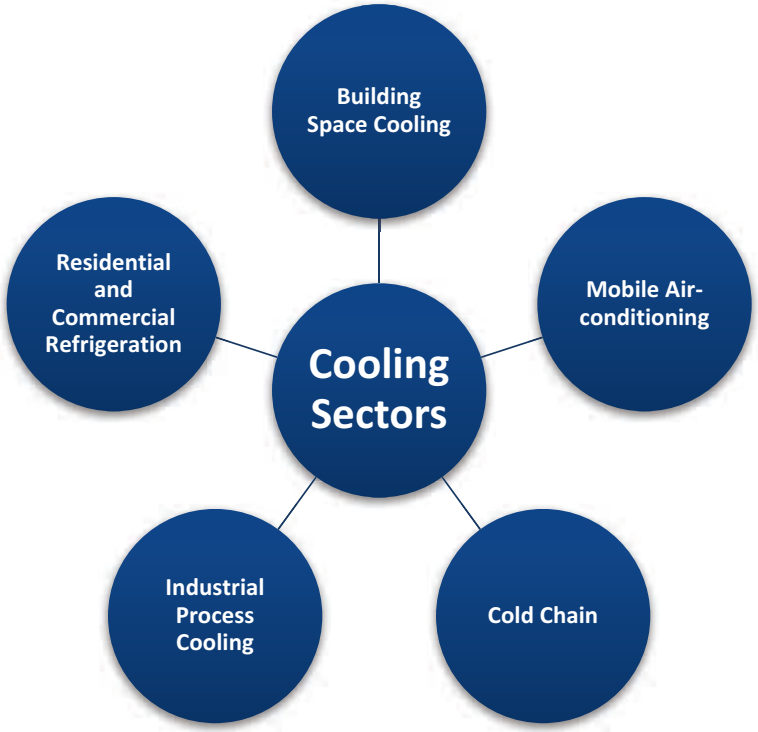


Key Initiative 3: Demand Analysis of Cooling in India for 2017 and 2027

First time in India, a **comprehensive view of nationwide cooling energy needs from various sectors**

Aggregation of cooling demand and emission impact by 2027, looking at **Business-as-usual and Improved scenario**

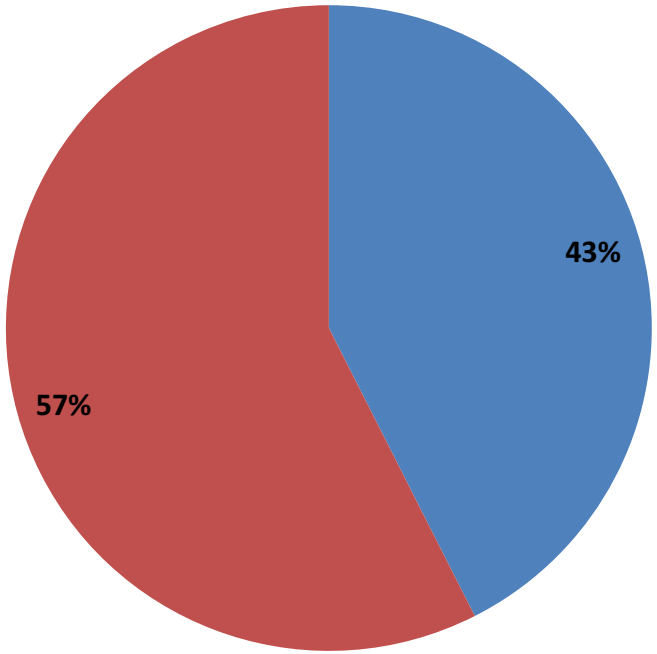
The methodology comprises multiple input sources, top-down and bottom-up validations, and key inputs and assumptions based on expert consultations



THIS STUDY FORMS THE CRITICAL STARTING POINT FOR THE NATIONAL COOLING ACTION PLAN CONVERSATIONS

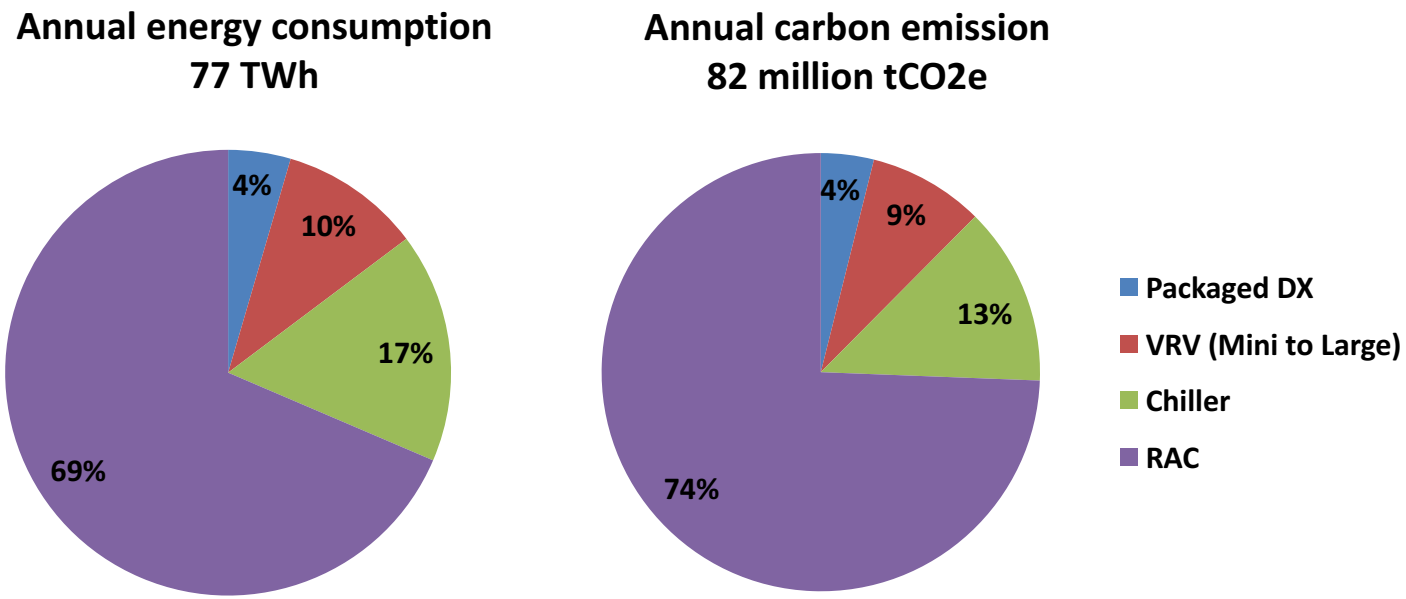
Building Space Cooling: Preliminary Results

2017 Annual energy consumption = 134 TWh

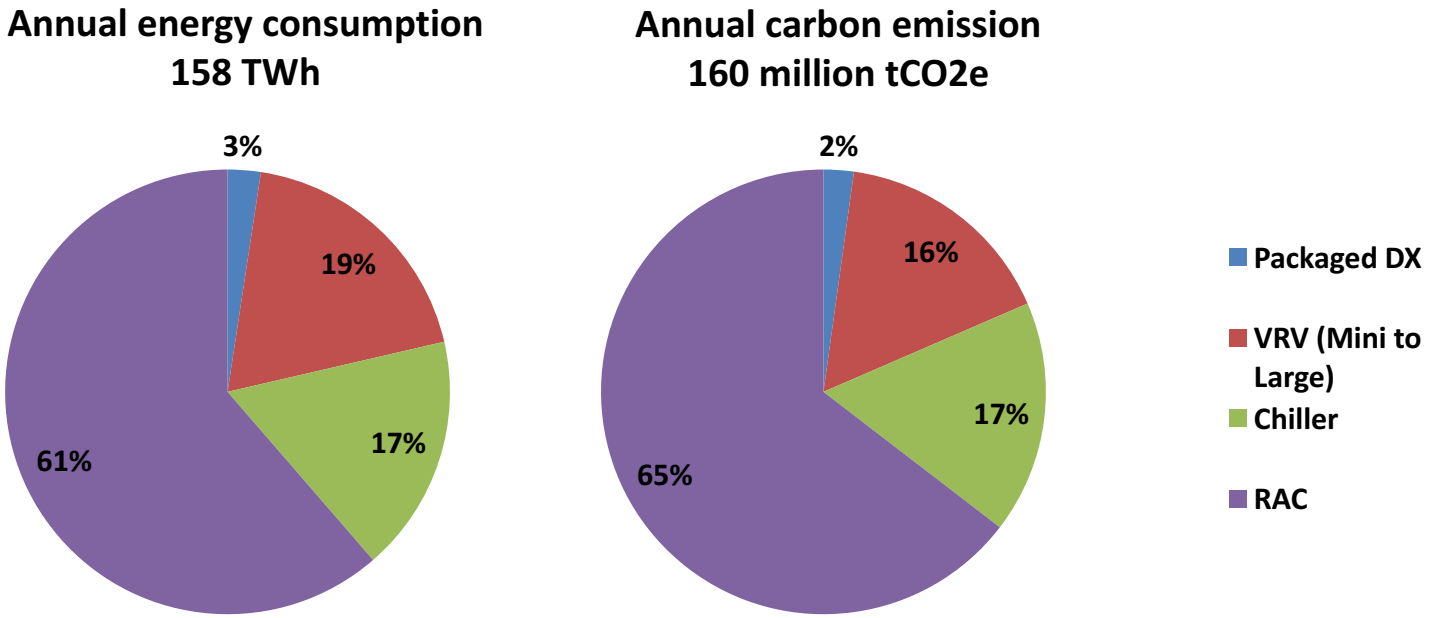


- **Non-refrigerant based cooling (fan and air cooler)**
- **Refrigerant based cooling (RAC, chiller, packaged DX, VRV)**

2017 Scenario: Air-conditioning in Buildings



2027 (BAU) Scenario: Air-conditioning in Buildings

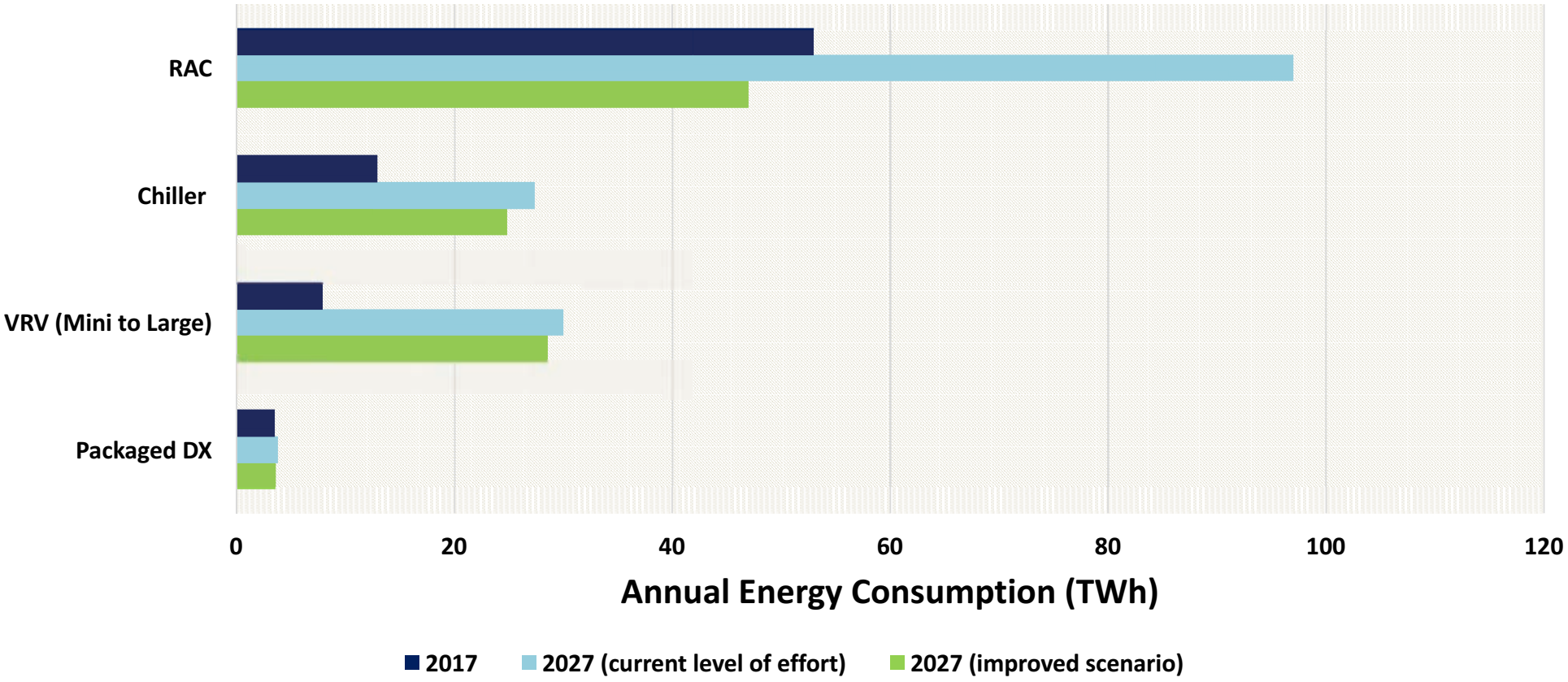


2017 and 2027 (BAU) Scenarios: RAC Penetration in the Residential Sector

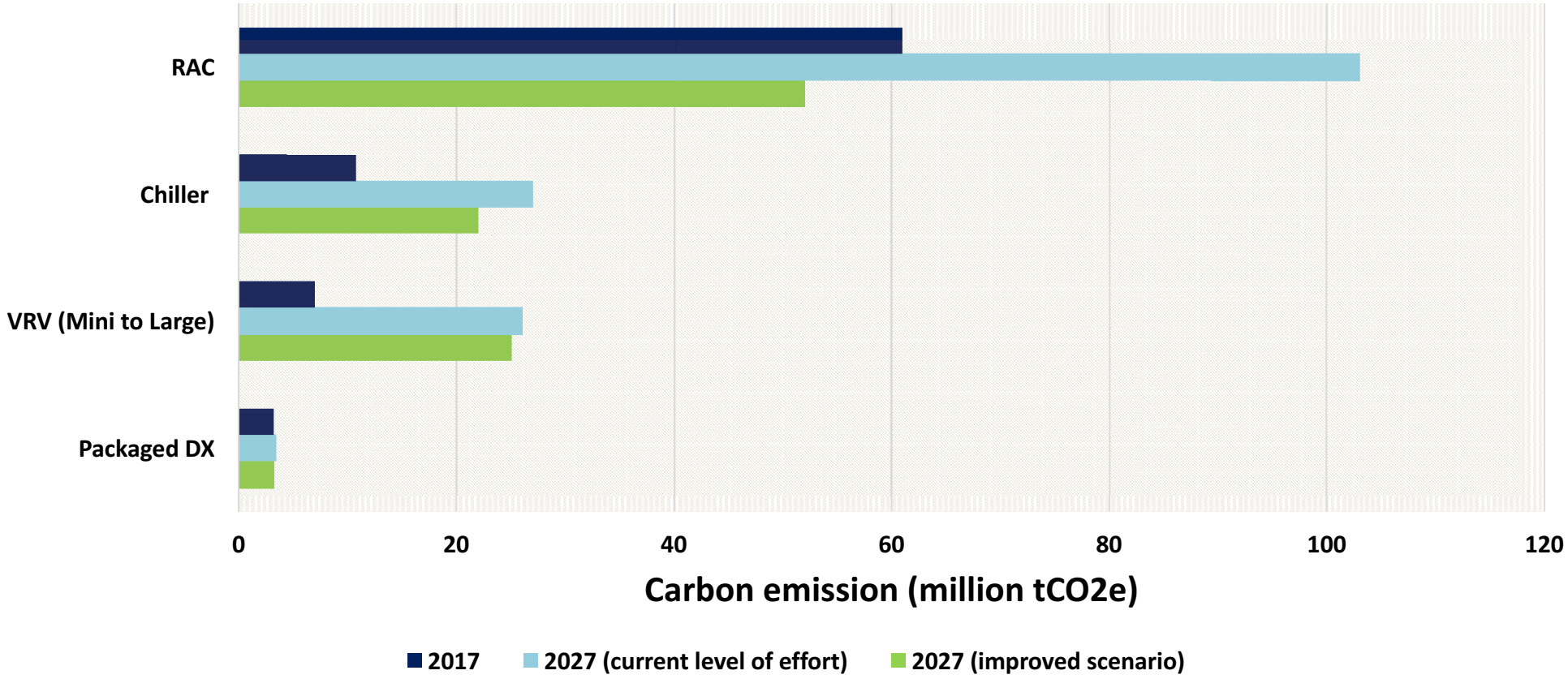
2017		
RAC stock	37 million units	Compiled from sales data
RAC stock deployed in residences	22 million units	@60%; sourced from LBNL and AEEE's own estimates
# of Households	268 million	Extrapolated from Census data
# of RACs per household	1.2	Prayas (2012)
RACs penetration	**7%**	

2027 (BAU)		
RAC stock	77 million units	Estimated from sales projections
RAC stock deployed in residences	54 million units	@70%; based on stakeholder input
# of Households	296 million	Extrapolated from Census data
# of RACs per household	1.2	Prayas (2012)
RACs penetration	**15%**	

Looking ahead: 34% energy saving is possible under Improved Scenario



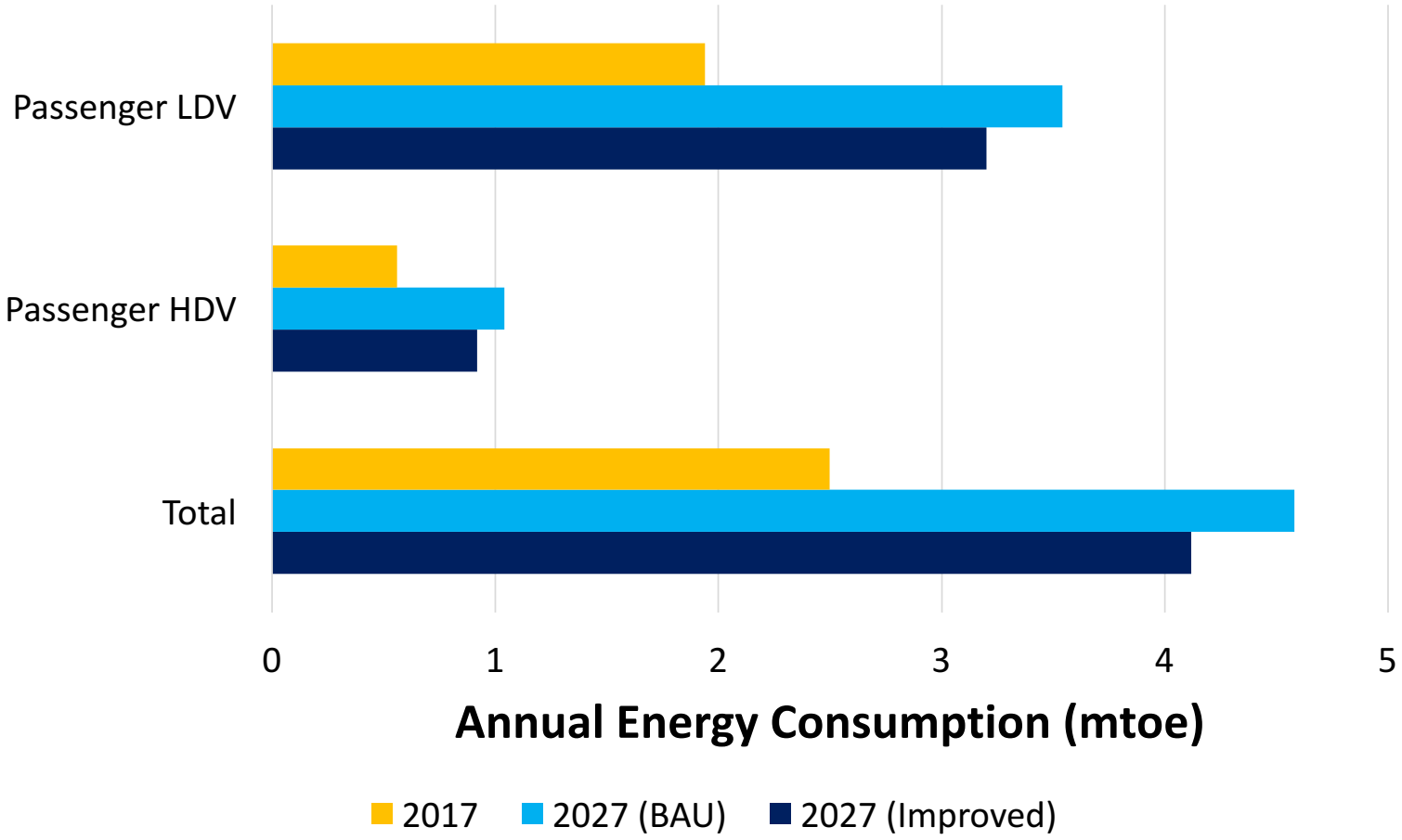
Looking ahead: 36% carbon saving is possible under Improved Scenario



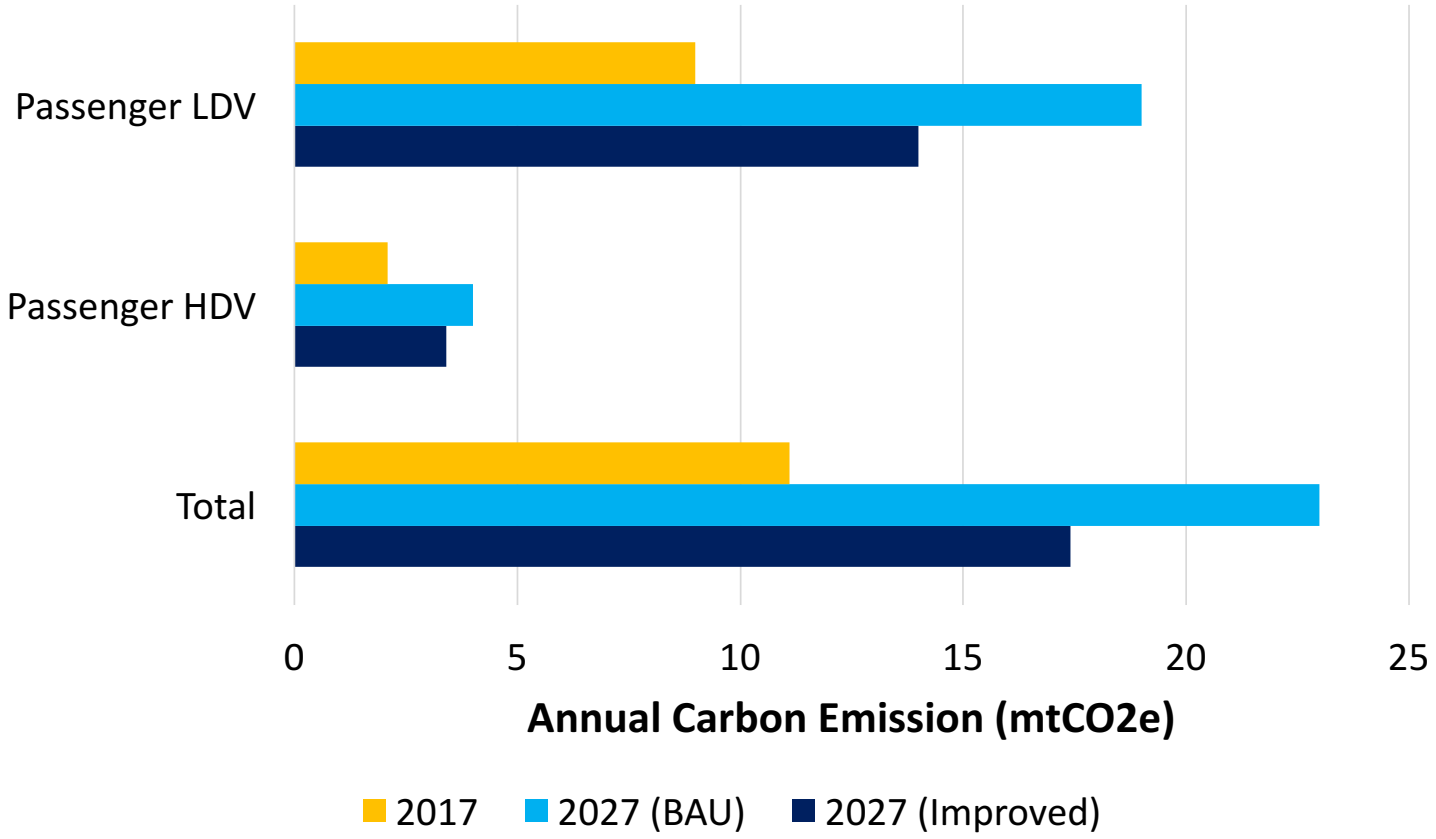
RAC Analysis: Key Results

	2017	2027 (BAU)	2027 (Improved)
Installed capacity (million TR)	56	116	113
Annual energy consumption (TWh)	53	97	46
Indirect emissions ($mtCO_2e$) [share of total]	43 [71%]	79 [77%]	38 [73%]
Direct emissions ($mtCO_2e$) [share of total]	18 [29%]	24 [23%]	14 [27%]
Total emissions ($mtCO_2e$)	61	103	52

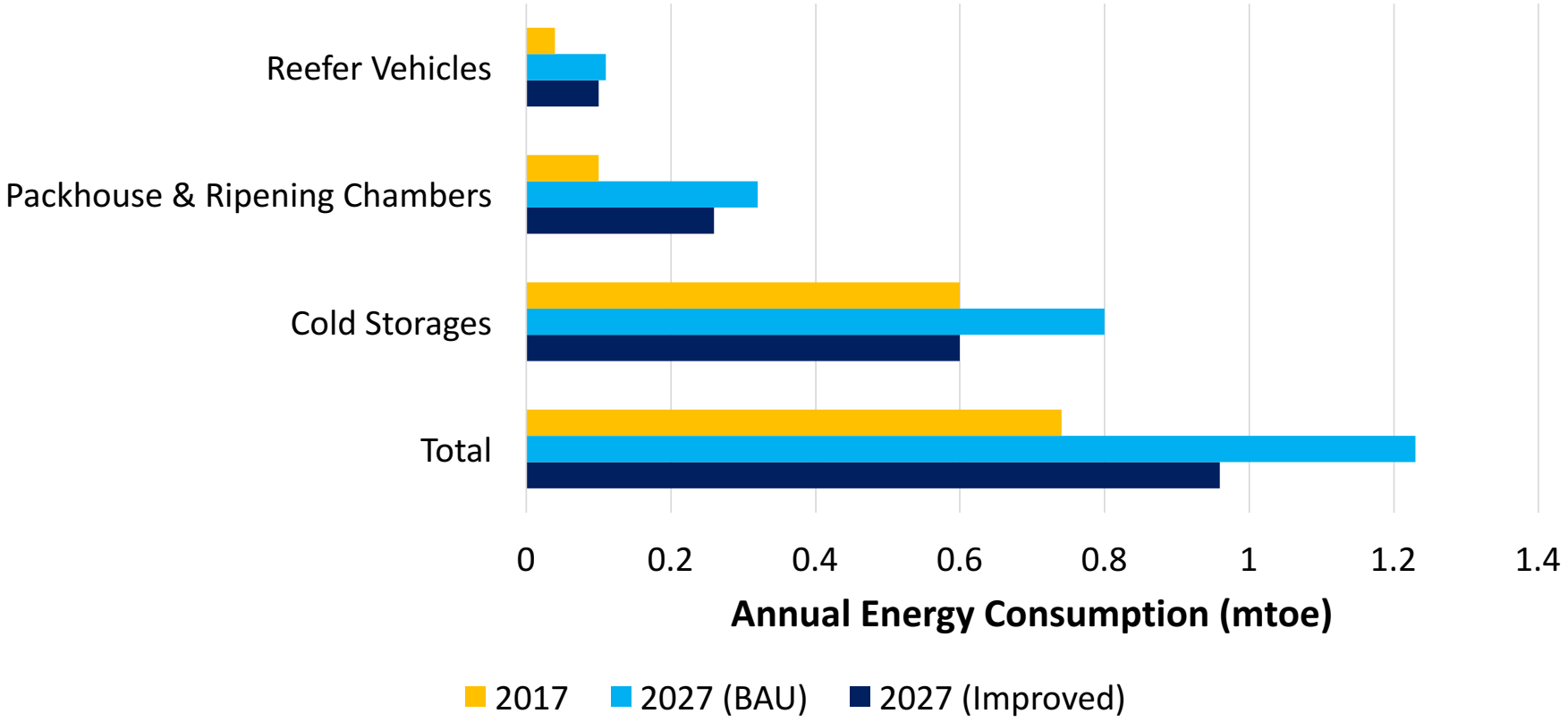
Mobile Air-conditioning: Preliminary Results – 10% energy saving is possible under the Improved Scenario



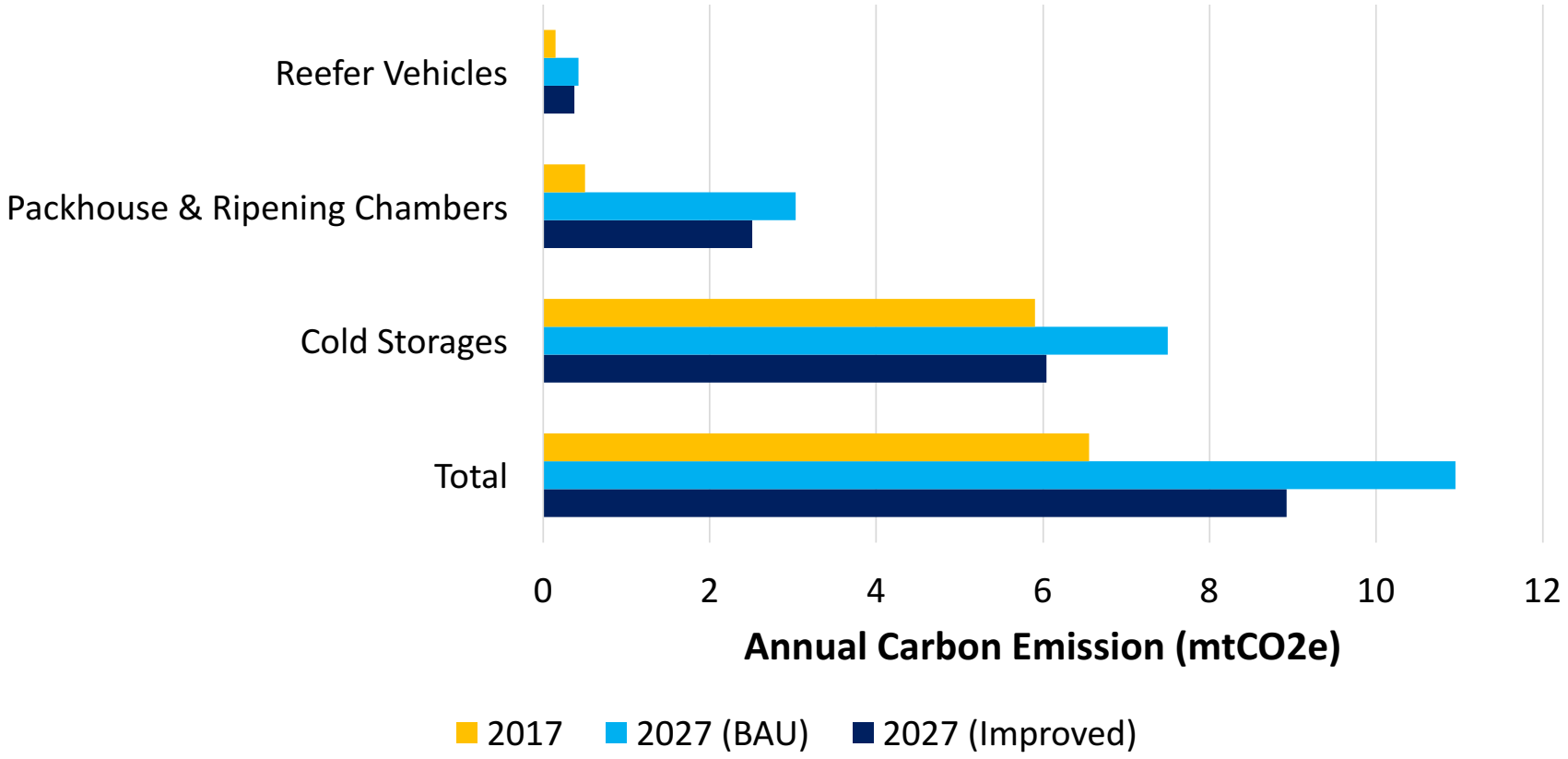
Mobile Air-conditioning: Preliminary Results – 24% carbon saving is possible under the Improved Scenario



Cold Chain: Preliminary Results - 22% energy saving is possible under the Improved Scenario



Cold Chain: Preliminary Results - 19% carbon saving is possible under the Improved Scenario



Improved Scenario

Improved Scenario incorporates:

1. Technology improvements
2. Efficient building strategies
3. Market interventions
4. Operations interventions
5. Behavioural changes
6. Alternate refrigerants
7. Better servicing practices

RAC

- **Ratcheting up the ISEER of RACs:** Equipment efficiency will have the strongest impact in the Improved Scenario
- **Envelope improvements in upcoming buildings that should reduce the need for active space cooling:** While the envisioned reduction in the total installed capacity is not large, the more significant reduction manifests in terms of reduction in run hours (due to increased uptake of code and Adaptive Thermal Comfort), which could be between 20% to 30% per our analysis

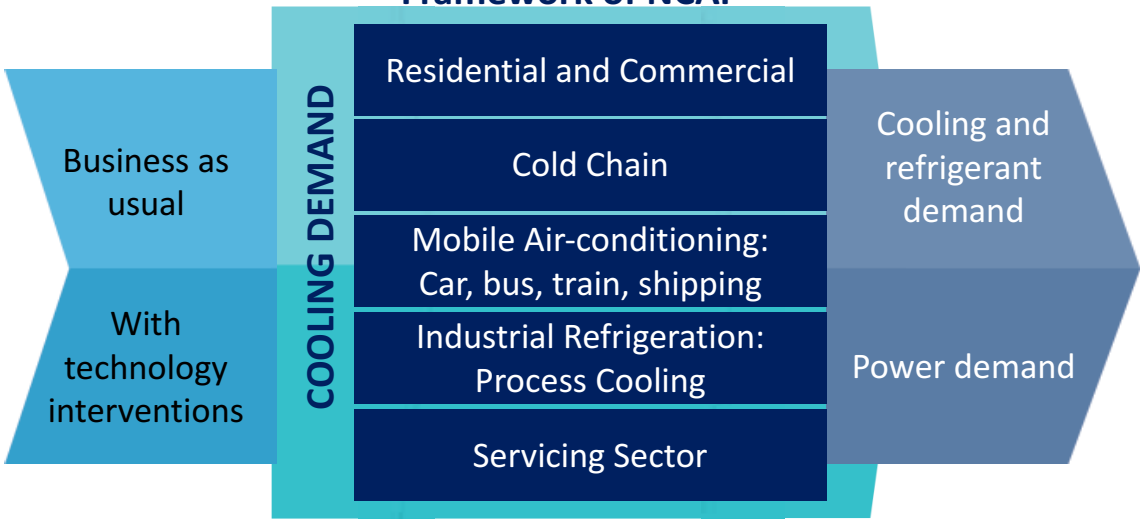
Chiller

- **Better O&M practices with focus on two important aspects:** HVAC O&M being a specialist's job, is better handled by trained HVAC engineers and technicians rather than generalists; utilization of Internet of Things (IoT) in day to day operations
- **Better uptake of ECBC-2017:** More buildings crossing the minimum ECBC compliance and even achieving ECBC EE and Super ECBC requirements

Key Initiative 4: Government of India's National Cooling Action Plan (NCAP)

- **Harmonizes Energy Efficiency and phase-out of ODS gases and phase-down of HFCs**
- Recognizes the **role of a multi-pronged strategy including reduction of Cooling load**
- Positions **Business and Technology as central to the development of a robust Cooling Action Plan for India**

Framework of NCAP



AEEE's Role

Determining the cooling demand analysis from the building sector with a sharp emphasis on space cooling and the role of Energy Efficiency in reducing and managing it

Leading the demand aggregation exercise in other thematic areas such as cold chains and MAC

Collaborating with the Ministry of Environment, Forest and Climate Change and other stakeholders of the National Cooling Action Plan to collate new findings into a coherent, robust and actionable roadmap

AEEE's Points of Alignment with NCAP

Even if the Montreal Protocol is more focused on refrigerants based cooling, it Is in India's interest to adopt a holistic approach to Cooling in order to meet its Sustainable Development Goals, to both mitigate and adapt to Climate Change while ensuring Thermal Comfort for All

In the light of significant increase (~3X) in building area by 2030 (from2010), India needs to build-in interventions to reduce the cooling demand itself

AEEE's Strategy

Whole is Greater than the Sum of Parts

Need For Integrated Solutions

DIMINISH THE NEED FOR ACTIVE AIR CONDITIONING: Energy efficiency policies as a lever; leveraging Codes (ECBC and ECBC-R) and S&L to reduce cooling demand; reduce direct and indirect emissions

ADVANCE COOLING TECHNOLOGIES: Efficiency improvement of ACs; alternative low-energy & non-refrigerant based cooling technologies; R&D to advance alternative cooling strategies

MARKET TRANSFORMATION: Behavioral shifts – adaptive thermal comfort; modify perceptions; Demand Response in conjunction with IoT strategies; financial & non financial tools to advance implementation

Hierarchical strategies and solutions – covering all three aspects – will multiply the positive impact & benefits

Questions?